Edexcel GCSE Physics

Topic 4: Waves

Notes

(Content in bold is for Higher Tier only)

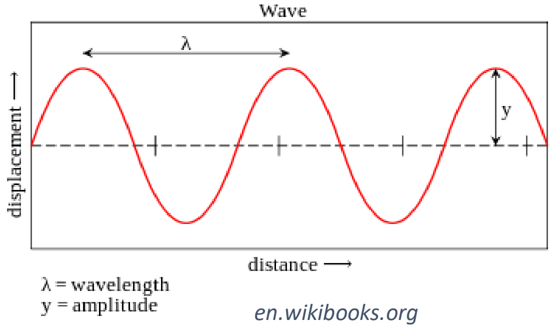
Waves and Energy

- Waves transfer energy without transferring matter
- This is shown in the sea, where buoys stay still despite waves passing by them – the waves move, but not the particles

Wavelength – distance between the same points on two consecutive waves,
Amplitude – distance from equilibrium line to the maximum displacement (crest or trough)
Frequency – the number of waves that pass a single point per second
Period – the time taken for a whole wave to completely pass a single point
Wavefront – the plane in which the wave travels (i.e. the direction of the wave)

$$\text{velocity} = \text{frequency} \times \text{wavelength} = v = f\lambda$$

Wave speed (metre/second, m/s) = frequency (hertz, Hz) × wavelength (metre, m)



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Relationships

- Increase frequency, velocity increases
- Wavelength increases, velocity increases
- Period is inversely proportional to frequency
- Smaller period, higher frequency, greater velocity

Types of Waves

- Transverse waves
  - Light, or any electromagnetic wave, seismic S waves, water waves
  - Has peaks and troughs
  - Vibrations are at right angles to the direction of travel
- Longitudinal waves
  - Sound waves, seismic P waves
  - Has compressions and rarefactions
  - Vibrations are in the same direction as the direction of travel

Measuring velocity

- Sound in air
  - Make a noise at ~50m from a solid wall, and record time for the echo to be heard, then use speed = distance/time
  - Have two microphones connected to a datalogger at a large distance apart, and record the time difference between a sound passing from one to the other – then use speed = distance/time
- Ripples on water surface
  - Use a stroboscope, which has the same frequency as the water waves, then measure distance between the 'fixed' ripples and use $v = f\lambda$
  - Move a pencil along the paper at the same speed as a wavefront, and measure the time taken to draw this line and the length of the line – then use speed = distance/time

Refraction

- Waves pass from one medium to another
- If passing into a more optically denser medium (from air to glass)
    - The wave will be refracted at the boundary and will change direction to bend towards the normal
    - **Speed decreases**
    - **Wavelength decreases**
    - **Energy of a wave is constant, and energy is directly linked to frequency of a wave. So if frequency is constant and speed decreases, wavelength must also decrease**
- **The light bends closer to the normal**

Reflection

- Waves will reflect off a flat surface
  (Physics Only)
- The smoother the surface, the stronger the reflected wave is
- Rough surfaces scatter the light in all directions, so appear matt and not reflective
- The angle of incidence = angle of reflection
- Light will reflect if the object is opaque and is not absorbed by the material
    - The electrons will absorb the light energy, then reemit it as a reflected wave

Transmission (Physics Only)

- Waves will pass through a transparent material
- The more transparent, the more light will pass through the material
- It can still refract, but the process of passing through the material and still emerging is transmission

Absorption (Physics Only)

- If the frequency of light matches the energy levels of the electrons
- The light will be absorbed by the electrons and not reemitted
- They will be absorbed, and then reemitted over time as heat
- So that particular frequency has been absorbed
- If a material appears green, only green light has been reflected, and the rest of the frequencies in visible light have been absorbed

Effect of Wavelength

- **Different substances may absorb, transmit, refract or reflect waves depending on their wavelength**
    - **Glass transmits/refracts visible light**
    - **Reflects UV**

The Ear (Physics only)

- **Outer ear collects the sound and channels it down the ear canal**
- **As it travels down, it still is a pressure air wave**
- **The sound waves hit the eardrum**
    - **Tightly stretched membrane which vibrates as the incoming pressure waves reach it**
    - **The eardrum vibrates at the same frequency as the sound wave**
    - **The small bones connected to this also vibrate at the same frequency (stirrup bone)**
- **Vibrations of the bones transmitted to the fluid in the inner ear (the cochlea)**
- **Compression waves are thus transferred to the fluid**

- The small bones act as an amplifier of the sound waves the eardrum receives
- As the fluid moves due to the compression waves, the small hairs that line the cochlea move too
- Each hair is sensitive to different sound frequencies, so some move more than others for certain frequencies
    - The hairs each come from a nerve cell
- When a certain frequency is received, the hair attuned to that specific frequency moves a lot, releasing an electrical impulse to the brain, which interprets this to a sound

- The higher the frequency, the more energy the wave has – which would damage cells in the ear more quickly, and would not be able to work effectively long-term
    - This, and the fact that we have evolved not needing to hear very high or low frequencies, means the ear only works for a limited frequency range

Ultrasound (Physics only)

- This is a sound wave with a higher frequency than 20 000Hz
- Uses:
    - Sonar
        - Pulse of ultrasound is sent below a ship, and the time taken for it to reflect and reach the ship can be used to calculate the depth
        - This is used to work out whether there is a shoal of fish below the ship
        - Or how far the seabed is below the ship
    - Foetal Scanning
        - Non-invasive and not harmful
        - Used to create an image of the foetus, allowing measurements to be made to check the foetus is developing normally
        - This works because ultrasound waves partially reflect at each surface boundary, this can be used to work out the distances and therefore an image of the foetus

Infrasound (Physics Only)

- Infrasound is the opposite of ultrasound – it is a sound wave with a frequency lower than 20Hz – also known as seismic waves. There are two: P and S waves
    - This is used to explore the Earth's core
    - P waves are longitudinal, and can pass through solids and liquids
    - S waves are transverse, only passing through solids (these move slower too)
    - On the opposite side of the Earth to an earthquake, only P waves are detected, suggesting the core of the Earth is liquid – hence no S waves can penetrate it